



RECORDER MANUAL

RUSTRAK Instrument Div. • GULTON Industries Inc.
Manchester, New Hampshire 03103. (603) 623-3591

RECEIVING

Your recorder has been carefully packaged at the factory to guard against damage in shipping. Each polyfoam case contains:

A Recorder
Hardware Kit
One roll of Chart Paper
One Manual

Missing items should be reported to your distributor immediately.

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Rustrak warrants each instrument of its manufacture to be free from defects in material and workmanship under normal usage and service for a period of one year after its initial purchase from the factory or an authorized Rustrak representative or distributor. Our obligation under this warranty is limited to repairing or replacing any instrument or component which, upon examination by factory personnel, is found not to conform to the foregoing warranty providing said instrument is returned to the factory, transportation prepaid. We shall not otherwise be liable for any damages, consequential or otherwise.

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Manual No. 17005

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AC RECORDER

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INTRODUCTION

This manual covers the AC group of recorder series manufactured by Rustrak, a division of Gulton Industries, Inc. The first part of the manual discusses instructions common to all recorders in this group. Later sections concern themselves with individual instruments while final pages add useful information for all recorders.

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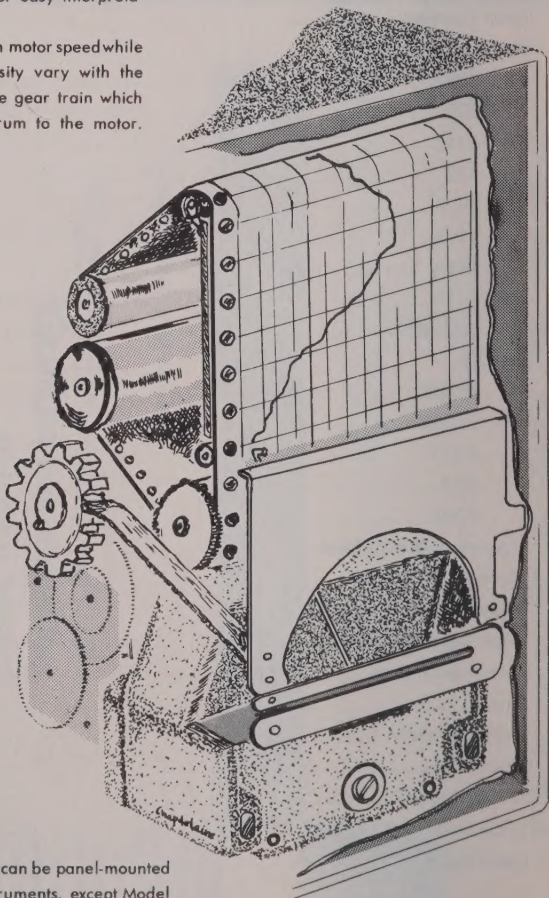
AC RECORDERS

A permanent magnet, moving coil meter driven by rectifier or transducer circuitry is used in each Rustrak AC recorder. Input signal magnitude determines the angular position of the stylus.

Each time the chopper bar, actuated by the motor cam, presses the stylus against the pressure-sensitive chart paper, recording occurs as a small dot. While the dots are being printed, the chart paper moves at the speed controlled by the gear train ratio. The trace appears as a continuous line but is formed by a series of dots.

Recording on the chord of the stylus arc by the edge of the chopper bar is possible with a stylus able to write along its length rather than its point. For that reason, Rustrak chart paper is printed with straight lines and recordings are rectilinear for easy interpretation.

Writing speed depends on motor speed while chart speed and trace density vary with the ratio of the interchangeable gear train which couples the paper drive drum to the motor.



All models described can be panel-mounted or used as portable instruments, except Model 2113 which is devised for portable use only. Be sure to check the nameplate on your recorder for features covered in this manual.

MOUNTING

Your recorder can be panel-mounted or used as a portable instrument. All necessary parts are included in the hardware kit.

Portable

Select four (4) rubber feet, four (4) 4-40X $\frac{1}{4}$ " screws and the white plastic cardholder from hardware kit. (Keep cardboard sleeve and other parts for later use.) Snap cardholder into holes at top of recorder. Install rubber feet at bottom of case using four screws selected.

Rack or Panel

(If recorder is to be mounted using Rustrak Model 2196 Escutcheon, DO NOT DRILL HOLES IN PANEL, and follow instructions accompanying escutcheon.)

From hardware kit, select two (2) aluminum brackets, two (2) 8-32 X $\frac{5}{16}$ " panhead screws, two (2) 8-32 X $\frac{1}{4}$ " panhead screws and two (2) flat speed nuts.

Refer to Figure 1 and assemble brackets to recorder using $\frac{5}{16}$ " screws and speed nuts at top. Use shorter screws at bottom.

Recorder can now be mounted to Model 2176 series panels. For custom mounting (without using 2196 Escutcheon), drill holes in panel as indicated on template (see inside back cover) and use three "J" type speed nuts supplied.

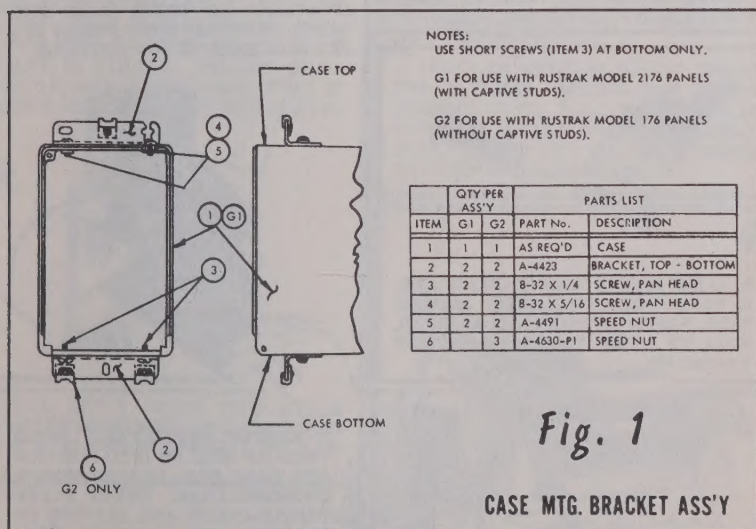
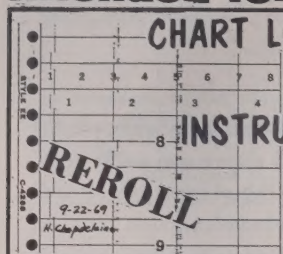


Chart Loading

Recorder must be loaded with chart paper before operating. Select desired mode (reroll or tear-off) of operation and load using following steps: (Use cardboard sleeve in reroll operation).



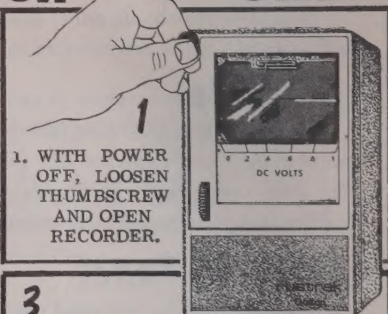
CHART LOADING



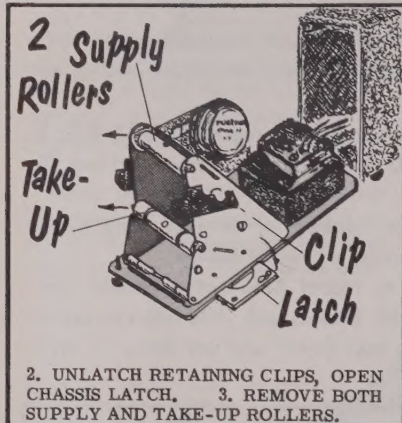
INSTRUCTIONS

USES
CARDBOARD
SLEEVE,
NOT BELTS.

9-22-69
H. Chapman



1. WITH POWER OFF, LOOSEN THUMBSCREW AND OPEN RECORDER.



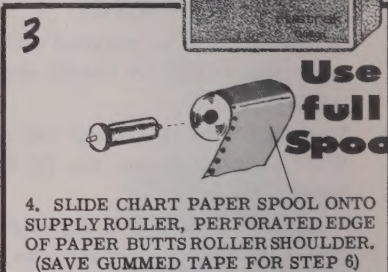
2 Supply Rollers

Take-Up

Clip

Latch

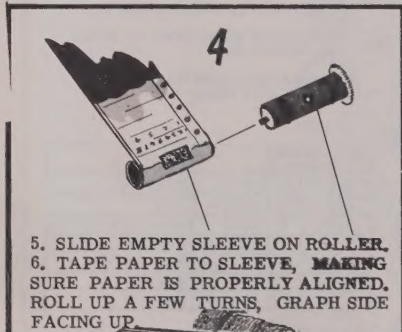
2. UNLATCH RETAINING CLIPS, OPEN CHASSIS LATCH. 3. REMOVE BOTH SUPPLY AND TAKE-UP ROLLERS.



3

Use full Spool

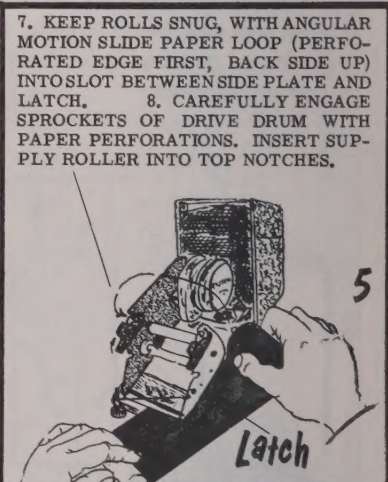
4. SLIDE CHART PAPER SPOOL ONTO SUPPLY ROLLER, PERFORATED EDGE OF PAPER BUTTS ROLLER SHOULDER. (SAVE GUMMED TAPE FOR STEP 6)



4

5. SLIDE EMPTY SLEEVE ON ROLLER.

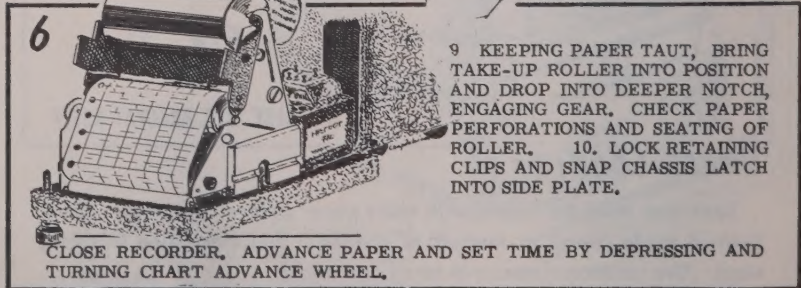
6. TAPE PAPER TO SLEEVE, MAKING SURE PAPER IS PROPERLY ALIGNED. ROLL UP A FEW TURNS, GRAPH SIDE FACING UP.



5

7. KEEP ROLLS SNUG, WITH ANGULAR MOTION SLIDE PAPER LOOP (PERFORATED EDGE FIRST, BACK SIDE UP) INTO SLOT BETWEEN SIDE PLATE AND LATCH. 8. CAREFULLY ENGAGE SPROCKETS OF DRIVE DRUM WITH PAPER PERFORATIONS. INSERT SUPPLY ROLLER INTO TOP NOTCHES.

Latch



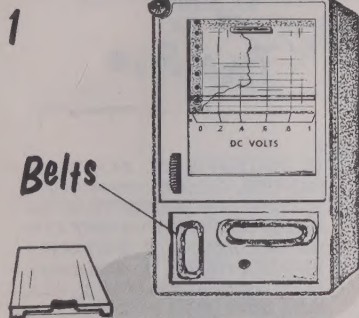
6

9. KEEPING PAPER TAUT, BRING TAKE-UP ROLLER INTO POSITION AND DROP INTO DEEPER NOTCH, ENGAGING GEAR. CHECK PAPER PERFORATIONS AND SEATING OF ROLLER. 10. LOCK RETAINING CLIPS AND SNAP CHASSIS LATCH INTO SIDE PLATE.

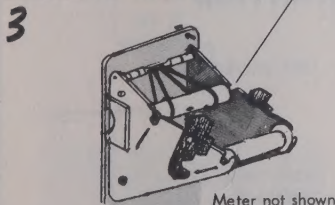
CLOSE RECORDER. ADVANCE PAPER AND SET TIME BY DEPRESSING AND TURNING CHART ADVANCE WHEEL.

**SAVE
CARDBOARD SLEEVE
FOR REROLL MODE USE.**

1. SNAP OUT NAMEPLATE PANEL USING FINE SCREWDRIVER. REMOVE DRIVE BELTS AND REPLACE NAMEPLATE.
2. OPEN RECORDER BY LOOSENING KNURLED THUMBSCREW.



5. UNLATCH RETAINING CLIPS, REMOVE TAKE-UP ROLLER. MAKE SURE CARDBOARD SLEEVE IS OFF ROLLER.
6. PASS ROLLER THRU BELTS, SEAT ROLLER IN PLATES. ROLLER GEAR MUST ENGAGE IDLER GEAR; SEAT IN DEEPER NOTCH OF LEFT SIDE PLATE.



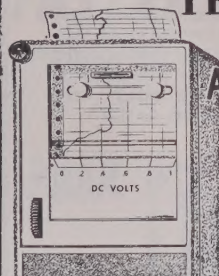
7. PULL DRIVE BELTS INTO LARGE CHAMFERED GROOVE OF GUIDE ROLLER & 'V' SLOTS ON TAKE-UP ROLLER.

PARTIALLY-USED ROLL OF CHART PAPER WILL OPERATE TEAR-OFF. USE ONLY FULL 63 FOOT ROLL FOR REROLL.

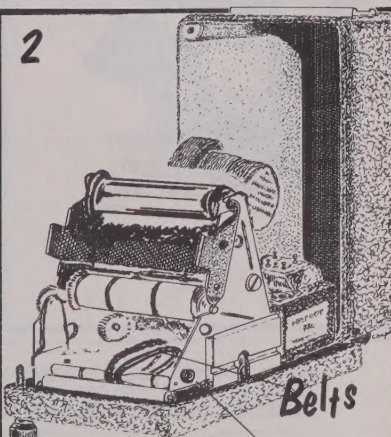
9-28-69 H. Chapdelaine

TEAR-OFF AN ALTERNATE MODE

USES
DRIVE BELTS

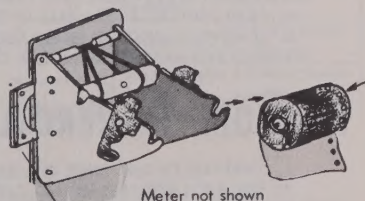


2



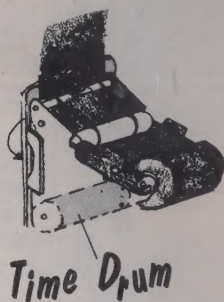
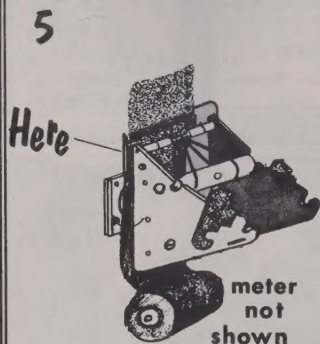
3. UNSCREW RELEASE SCREW TWO OR THREE TURNS. SPRING SIDE PLATE, REMOVE GUIDE ROLLER.
4. SLIP ROLLER THROUGH BELTS, REINSERT ROLLER INTO SIDE PLATE. FINGER TIGHTEN RELEASE SCREW.

4



8. OPEN LATCH. REMOVE ROLLER AND INSERT INTO SPOOL OF CHART PAPER. PERFORATED EDGE OF PAPER MUST BUTT ROLLER SHOULDER.

9. UNROLL ABOUT SIX INCHES OF PAPER. WITH AN ANGULAR MOTION SLIDE PAPER (PERFORATED EDGES FIRST, BACK SIDE UP) INTO SLOT BETWEEN THE RIGHT SIDE PLATE AND CHASSIS LATCH.



10. SEAT SUPPLY ROLL IN NOTCHES PROVIDED, CLOSE RETAINING CLIPS.
11. CAREFULLY ENGAGE CHART PAPER PERFORATIONS WITH SPROCKETS ON TIME DRUM. 12. SNAP LATCH INTO SIDE PLATE. 13. WITH CHART PAPER UNDER GUIDE ROLLER, PULL BOTH DRIVE BELTS INTO SMALL 'V' SLOTS ON GUIDE ROLLER.

9-24-69 H. Chapdelaine -

CLOSE RECORDER, TIGHTEN THUMBSCREW. WITH POWER APPLIED, RECORDER IS READY FOR TEAR-OFF OPERATION. ADVANCE PAPER AND SET TIME BY DEPRESSING AND TURNING CHART ADVANCE WHEEL.

CONVERSION INFORMATION

REROLL TO TEAR-OFF

USES DRIVE BELTS.

1. OPEN RECORDER. DROP CHASSIS LATCH.
2. UNLATCH BOTH RETAINING CLIPS.
3. REMOVE SUPPLY ROLL AND TAKE-UP ROLL. CLEAR THEM.
4. FIND DRIVE BELTS IN WELLS UNDER FRONT NAMEPLATE.
5. REMOVE CARDBOARD SLEEVE FROM TAKE-UP ROLLER.
6. PROCEED WITH STEP 3 IN TEAR-OFF LOADING INSTRUCTIONS.

TEAR-OFF TO REROLL

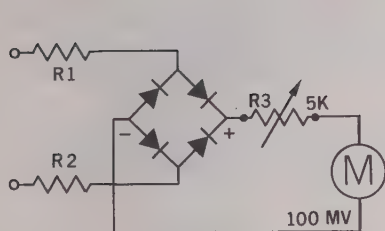
USES CARDBOARD SLEEVE.

1. OPEN RECORDER. DROP CHASSIS LATCH.
2. UNLATCH BOTH RETAINING CLIPS.
3. REMOVE SUPPLY ROLL AND CLEAR ROLLER.
4. SLIP OUT TAKE-UP ROLLER FROM WITHIN DRIVE BELTS.
5. UNSCREW KNURLED RELEASE SCREW, SWING OUT GUIDE ROLLER AND REMOVE BELTS.
6. REPLACE GUIDE ROLLER AND FINGER TIGHTEN KNURLED RELEASE SCREW.
7. STORE DRIVE BELTS IN WELLS PROVIDED UNDER FRONT NAMEPLATE.
8. CONTINUE WITH STEP 4 IN REROLL LOADING INSTRUCTIONS.

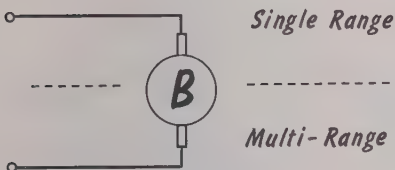
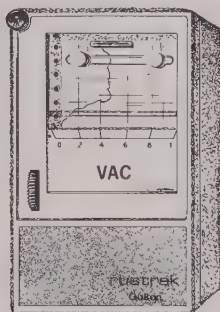
DO NOT OPERATE REROLL WITH LESS THAN 63 FOOT ROLL.

INDIVIDUAL INSTRUMENTS

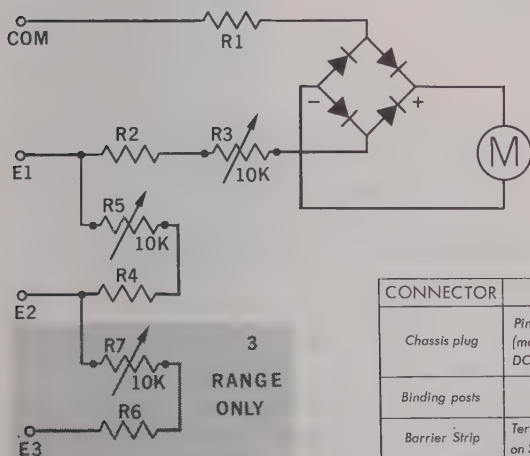
(with Description, Operation & Calibration)



288R



$R1=R2=434E1-2.5K\Omega$
 $R4=868(E2-E1)-5K\Omega$
 $R6=868(E3-E2)-5K\Omega$



Wiring...

CONNECTOR	MOTOR	METER
Chassis plug	Pins 3 & 4 (mostly used with DC motors)	Pin 1 common See label
Binding posts	Line Cord	Posts labeled on Case Rear
Barrier Strip	Terminals labeled on Strip	Terminals labeled on Strip

Refer to label inside recorder for correct wiring.

OPERATION:

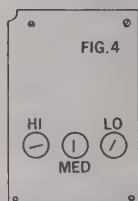
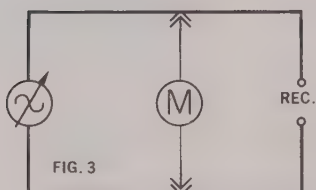
1. Connect motor to line and allow recorder to print several strikes. If trace isn't at zero, snap out front nameplate using screwdriver in slot at left and adjust mechanical zero.
2. Wire recorder to circuit under test, after reading directions inside recorder.
3. Switch on circuit to be monitored. Recorder can operate unattended until chart paper is depleted.

Calibration...

The Model 288R recorder is calibrated against a standard meter using a variable voltage source. See Figure 3.

Single Range:

1. Mechanically zero meter with motor running and no electrical signal input. Adjustment located under front nameplate.
2. Apply input voltage equivalent to recorder full scale and monitor on a standard meter.
3. Open recorder and lay on its side.
4. Adjust rheostat located inside case rear until recorder prints at full scale.



Multiple range:

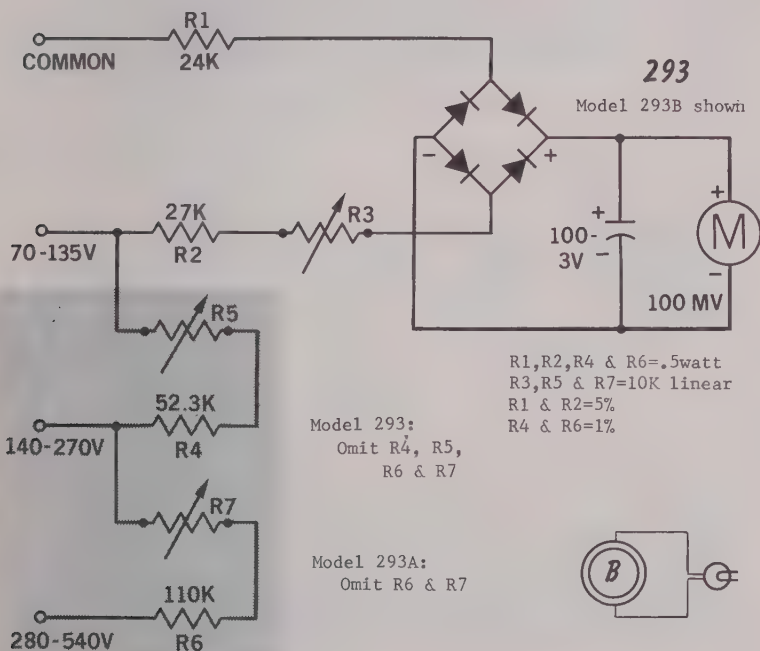
Recorders with two or three ranges must be calibrated in steps beginning with the lowest range. See Figure 4 for physical location of adjustments.

1. Mechanically zero meter with motor running and no electrical signal input. Adjustment located under front nameplate.
2. Apply input voltage equivalent to recorder full scale (on lowest range) and monitor on standard meter.
3. Open recorder and lay on its side.
4. Adjust rheostat located on circuit board at case rear (low range) until recorder prints at full scale. See Figure 4.
5. Switch input voltage and standard meter leads to second range binding posts. Increase input voltage to equivalent of full scale reading.
6. Adjust center rheostat until recorder prints at full scale. *Do not readjust low range rheostat.*
7. If recorder has three ranges, make connections (as before) to high range terminals. Adjust voltage to equivalent of full scale reading, always monitoring on the standard meter.
8. Adjust left hand rheostat (see figure 4) until trace prints at full scale. *Don't adjust other two rheostats.*

Recorder is now calibrated and ready to use.

293 (ALL)

This series of single channel AC voltage recorders features a suppressed galvanometer movement for high resolution readings of commercial line voltages. Suffix "A" instruments are dual range while "B" suffixed recorders have three ranges. Input impedance on all ranges is 800 ohms per volt with an accuracy of 3 percent. Ranges are 70-135, 140-270 and 280-540 VAC.



Wiring

Drive motor connections are made through a permanent line cord and range terminals are binding posts on the case rear. Binding posts are labeled for voltage ranges.

Operation & Calibration

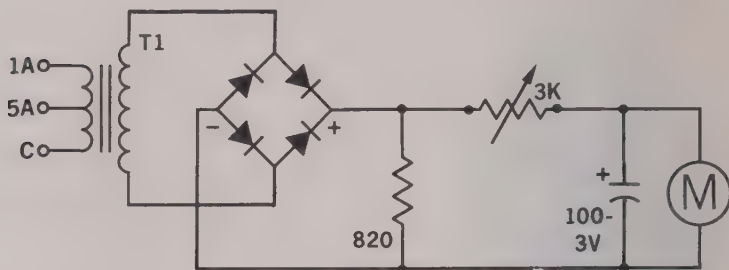
Refer to multiple range model 288R.

Don't zero meter with no input. Adjust zero only with minimum voltage applied, e.g., 70V, 140V or 280V depending on range. Mechanically suppressed galvanometer will not adjust with zero input.

2118

The Model 2118 is a single channel recorder for use with an external current transformer or for recording currents to 5 Amperes directly. Dual range, the instrument also has a 1 Amp input for other transformer multiplication factors.

Simple in design, the recorder uses a 100 mv. permanent magnet, moving coil movement fed by a bridge rectifier through a 3K pot, the calibration control. The input transformer primary matches the 5 Amp winding of a current transformer and the secondary drives the bridge rectifier. Input resistance is 0.009 ohm on the 5 amp winding. Burden is 0.5 VA.



Wiring...

Each 2118 has a line cord permanently attached for drive motor connections. Refer to inside tag for correct voltages. Binding posts on the case rear are labeled "Common," "1 Amp," and "5 Amp."

Operation...

1. Apply motor power and allow unit to print several strikes to be sure stylus is zeroed. If it isn't, snap out front nameplate and mechanically zero the meter.
2. Wire recorder to 5 Amp winding of current transformer (no power applied to primory) using posts labeled "Common" and "5 Amp" or in series with circuit to be tested. Observe safety precautions. No polarity need be observed.
3. Switch on circuit to be monitored. Check recorder for on-scale print-out. Instrument records as long as power is applied or until paper supply is depleted.

Calibration...

Besides the mechanical zero, a 3K pot on the inside case rear is provided for electrical calibration. Always zero the meter mechanically before attempting electrical calibration.

There are several ways to calibrate the Model 2118 and choice of method depends on available equipment and accuracy needed.

Method A: AC Ammeter (See Figure 5)

Wire an accurate AC Ammeter in series with the Model 2118 input terminals, a 1 ohm 25 watt 10% resistor and the secondary of a current (or filament) transformer rated at 5 Amps or more. Connect primary of transformer to a Variac or other variable AC source fed by sinusoidal signal (commercial line preferably) and increase input voltage until ammeter reads 5 Amps. Adjust 3K pot for print out (with recorder motor running) at 5 Amps full scale.

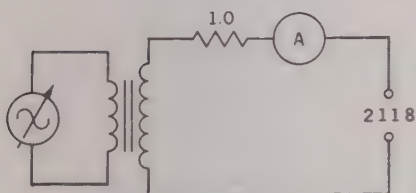
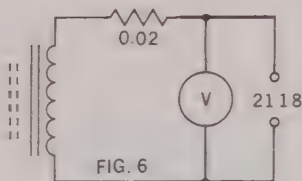


FIG. 5

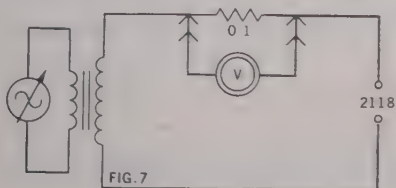


Method B: AC Millivoltmeter, 10% accuracy, (See Figure 6)

The input resistance of the 2118 is 0.009 ohms. With 5 Amps flowing in the primary winding, the voltage across the input should be 0.045 VAC. Using an accurate AC millivoltmeter of the VTVM type, adjust input Variac until voltmeter reads 0.045 V. then correct any deviation from full scale print out with 3K calibration pot on inside case rear of recorder.

Method C: AC Voltmeter (See Figure 7)

Read out a 0.1 ohm 2.5 watt resistor to 4 figures on a bridge. Wire resistor in series with input transformer 5 Amp winding and the Model 2118 input. Compute voltage drop across resistor (E equals IR) for 5 Amp current flow. Connect AC voltmeter across resistor. Increase voltage to primary of transformer until voltmeter reads computed voltage. Then adjust 3K pot inside recorder if print out is not at full scale.



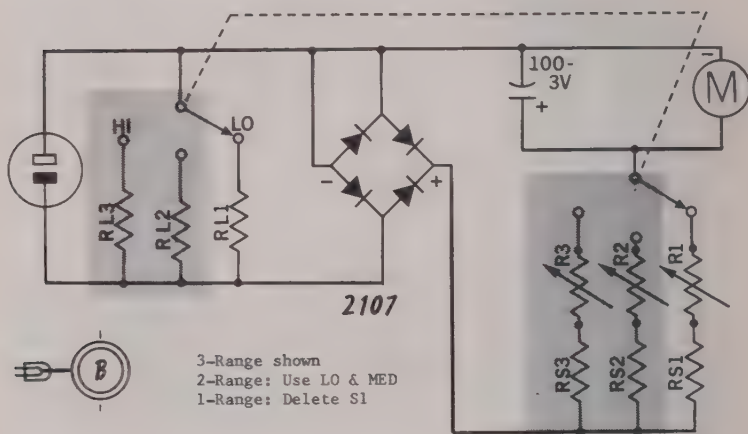
2107

The Model 2107 records line loads without breaking the circuit or interrupting machinery. Single channel, it features a split core snap-around current transducer for clamping on feed wires and a range switch on the case rear for multiple ranges.

Fed across RL, a load resistor (for linearity), the output of the current transducer is rectified by CR1, a bridge rectifier connected in half-wave configuration by shorting one bridge leg (for linearity). The 100 mv. (or 50 mv.) meter in series with a calibration multiplier responds to the average DC output of the rectifier.

Resistor values change with range and type of current transducer furnished with the instrument.

Since the current transducer is furnished with the instrument, no wiring is needed. The transducer's cable mates with a connector wired to the recorder. Motor connections are made through a line cord.



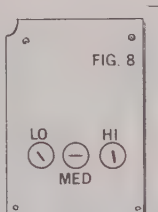
Operation...

1. Apply motor power and allow unit to print several strikes to be sure stylus is zeroed. If it isn't, snapout front nameplate and mechanically zero the meter.
2. Squeeze open jaws of current transducer and snap-close around current carrying wire. Be sure jaw tips interlock for low reluctance path.
3. Observe safety precautions when working with high voltage, high current circuitry.
4. Always clamp transducer around a single conductor, never a dual conductor such as Romex wire to a load.

Calibration...

A conductor carrying a known load is needed to properly calibrate the 2107. For practical reasons, an air core donut coil with tapped turns can be used. The number of turns known, the current through the coil is adjusted for an equivalent flux field (relative to flux around a current-carrying conductor). Because this coil is not readily available and accurate AC ammeters are scarce, we recommend our factory calibration.

Adjustment rheostats, located on the circuit board inside the instrument case rear, are depicted in Figure 8.



2120

E and I data are combined on one chart (1" chart width each channel) with the same time base in the Model 2120 Series AC recorder. Two galvanometers are used, each independently fed by its circuitry. The current half of this instrument houses a Model 2118 current recorder (less the 1 Amp. range) while the voltage recorder features a mechanically suppressed galvanometer for charting the more common commercial line voltages.

Refer to Model 2118 for schematic of the current portion. The voltage channel uses series precision resistors or the Model 293 circuitry.

Operation...

Refer to instructions for both the Model 288R and the Model 2118. The two mechanical zero adjustments are located under the nameplate and in-line with their respective meters.

Calibration...

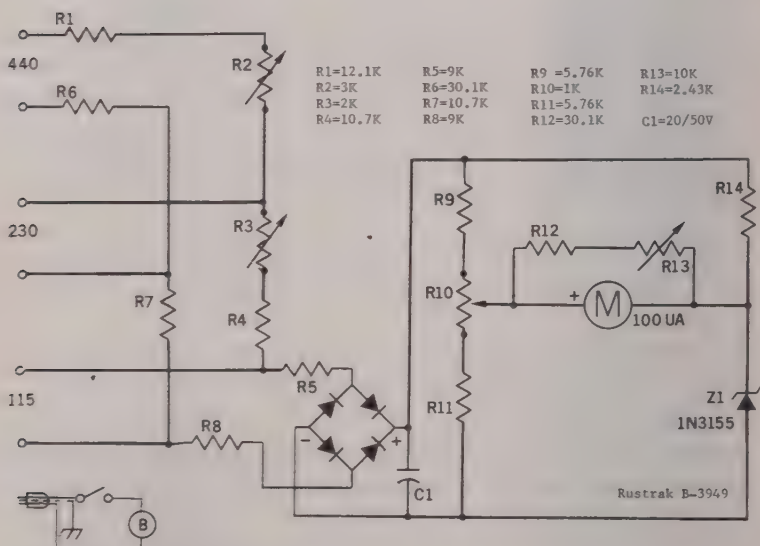
Binding posts are used for both the current and voltage channels with each post labeled for identification. A line cord is provided for the motor. Refer to label inside recorder for motor voltage and speed.

1. Refer to Model 2118 for current channel.
2. Voltage ranges cannot be calibrated (precision resistors being used) if your instrument is a catalog item. If you've purchased a special instrument, refer to Model 293 for calibration instructions.

2186

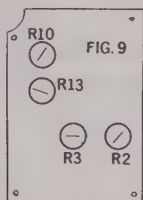
The Model 2186 is an expanded scale recording voltmeter with low ends of scales nulled out. Scales centered on nominal commercial line voltages have a resolution of 0.5 volt per division on the basic range and 2 volts per division on the 460 VAC range. The Model 2186 is a peak reading AC recorder calibrated in rms readings.

Each range has two binding posts located on the case rear. There is no provision for range switching. A three conductor line cord or blank end DC cable connects the motor to its power source.



Operation...

1. With no input to recorder, energize motor and let print several strikes to be sure stylus is zeroed. If it isn't, snap out front nameplate and mechanically zero the meter.
2. Connect circuit to be monitored to correct binding posts on case rear. Observe safety precautions.



Calibration...

Calibrate this recorder using the Model 288R hookup (see Figure 3). The standard meter must be accurate to 0.25 percent and input signal must be an undistorted sine wave. Use 40 division (Style H paper to calibrate.

1. Check mechanical zero and adjust if necessary.
2. Apply 106 VAC (as monitored on standard) to terminals marked 105-125 and adjust R10 (see Figure 9) for $\frac{1}{2}$ division BELOW 106.
3. Increase input voltage to 115 VAC and adjust R13 (see Fig. 9) for center scale recording.
4. Now increase input voltage to 124 VAC and check reading. Recorder should print within $\frac{1}{2}$ division of scale marking. If it doesn't, check steps 1, 2 and 3 again.
5. Change input and standard meter leads to posts labeled 210-250 and increase input voltage to 230 VAC. Adjust R3 (see Figure 9) for center scale printout.
6. Reduce voltage to 212 VAC and let unit print several strikes. Increase voltage to 248 VAC and again let unit print. In each case, the recorder should print within $\frac{1}{2}$ division of input voltage.
7. Again change input and standard meter leads to binding posts marked 420-500 and adjust input voltage to 460 VAC. If recorder doesn't print out at 460, adjust R2 (see Fig. 9).
8. Now vary input voltage to 424 VAC and let unit print. Do the same at 496 VAC. In both cases, recorder should print within $\frac{1}{2}$ division of input voltage.

2164 Series...

The Model 2164 Series are recording dynamometers with a Hall effect transducer to measure power. This transducer is an indium arsenide crystal in the air gap of a magnetic circuit whose field depends on line current. A potential transformer applies a control current proportional to line voltage to the crystal. The output voltage is a product function of in-phase rms values of voltage and current. See Figure 10.

The output signal of the Hall effect transducer contains two elements: an AC component which is disregarded in metering applications, and a DC component proportional to watts or real power. In the Rustrak recording wattmeter, the output feeds a 100 ohm galvanometer through a series rheostat to match characteristics of individual transducers. See Figure 11.

Internally, the Hall effect transducers are encapsulated in cans with an 11-pin header. Multiple current and voltage windings minimize the number of cans required for the wattmeter series. Only the wiring to the pins changes with suffix numbers.

WIRING:

The outside wiring is standardized to four terminals of a barrier strip on the case rear and is shown in Figure 12 for all suffixes of the single phase Model 2164 wattmeters. Since the instrument is in series with the load, its wiring should be consistent with good engineering practice.

THE RECORDING VAR METER (Model 2164V)

The transducer output, like the scale of a dynamometer, is a product function capable of measuring reactive volt amps (VARs) if the phase relationship is correct.

If R_m in the dynamometer (see Figure 13) is replaced by a reactor, the moving coil current shifts 90 degrees with respect to line voltage. Torque is $EI \sin 0$ and the instrument reads imaginary power.

The same result is obtained in the Hall effect transducer by replacing the potential transformer with capacitors in series with the Hall crystal across the line. This shifts the phase by 90 degrees in the potential circuit. Because the reactance of the capacitors is inversely proportional to frequency, the varmeter can be used at only one specific frequency.

Model 2164V VARs recorders are available in single-phase and in ranges described by the 5, 6, 7 and 8 suffixes only. Wiring to the varmeter is shown in Figure 12, and wire sizes used should be capable of handling both real and imaginary power.

Polyphase Circuits:

The number of wattmeter elements necessary to measure polyphase power is one less than the number of lines in the load ($n-1$). Two elements are needed for a three wire system but three elements are used with a four wire system.

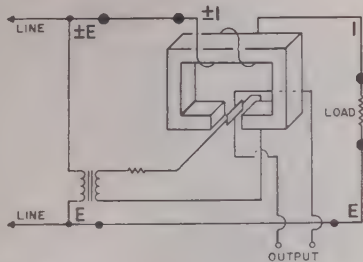


FIG. 10

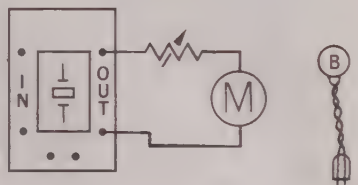


FIG. 11

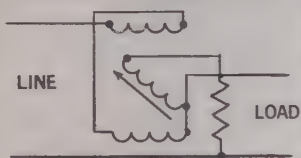
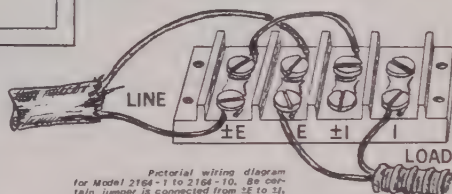


FIG. 13



Pictorial wiring diagram for Model 2164-1 to 2164-10. Be certain jumper is connected from E to I. Same wiring applies to Models 2164V-5 to 2164V-8.

FIG. 12

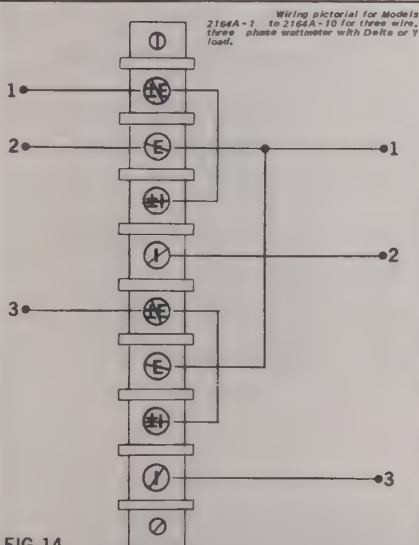
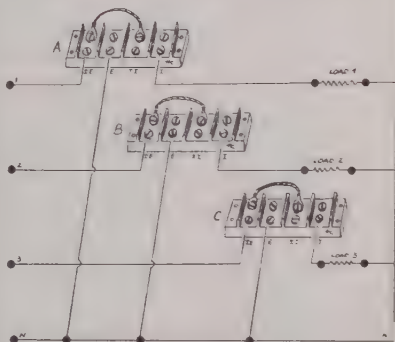


FIG. 14



Connections for Model 2164B, three phase, four wire system using three transformers. A jumper is connected between terminals ±E and I on each barrier strip.

FIG. 15

LOAD POWER RELATIONS

$$\begin{aligned} 1 \phi \text{ watt} &= E \times I \cos \theta & 3 \phi 3 \text{ wire watt} &= \sqrt{3} E_{L-L} I_L \cos \theta \\ 1 \phi \text{ var} &= E \times I \sin \theta & 3 \phi 4 \text{ wire watt} &= \sqrt{3} E_{L-L} I_L \cos \theta = \\ & & & 3 E_{L-N} I_L \cos \theta \end{aligned}$$

Power factor

$$\text{Power factor} = \frac{\text{watts}}{\text{volt-amperes}} = \frac{W}{VA} = \frac{W}{W \cos \theta} = \cos \theta$$

(for sine wave only)

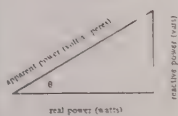


FIG. 16

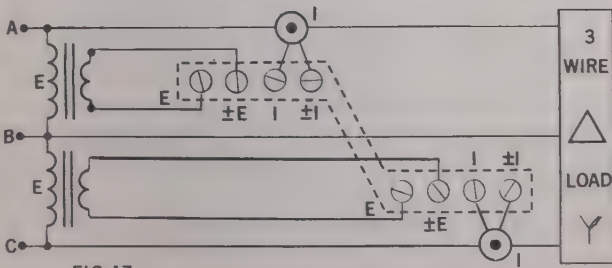


FIG. 17

OPERATING NOTES:

The operation of the recording wattmeter is similar to that of the more commonly known dynamometer. Fixed field coils in the dynamometer carry the full load current. A resistor is wired in series with the moving coil to make its field proportional to line voltage. See Figure 13. The current coil in the Hall effect transducer also carries the full line current but a potential transformer replaces the voltage winding.

As in the dynamometer, no power supply (except for the recorder motor) is needed to operate the wattmeter. (With a slight wiring change and the right choice of motor, the recorder can operate directly from the line providing the load of the motor is not objectionable). It operates from the line being measured and the power it consumes is called burden. Both current burden and voltage sensitivity in the Model 2164 depend on the output voltage which is fixed at 100 Mv. into a 100 ohm load. Current burden at 60 Hz is 2.5 VA with a voltage sensitivity of 100 ohms per volt.

Current overload on the transducer is twice rated current (momentarily). If danger of momentary shorting is possible, replace the jumper with a quick blow fuse. Voltage across the "E" terminals should not exceed 1.5 times rated voltage.

Reversing line and load connections (line to "I" and load to "E") will reverse meter polarity. Such reversal will not harm the transducer but, as may be appreciated, cannot help the recorder galvanometer.

RECORDER OPERATION:

1. Connect recorder motor to its power supply (after loading chart paper). Allow unit to print several strikes.
2. Zero meter (adjustment under front nameplate) if it isn't printing at zero.
3. Make certain wattmeter is correctly wired to line and load.
4. Switch on circuit to be monitored.

Burden: The amount of power drawn by the instrument from the circuit under test must be taken into consideration when calibrating the watt recorders against a dynamometer. Dynamometer coils require between 0.5 and 1 watt power to develop torque and often more on multi-range instruments. Check your standard dynamometer to compute burden accurately. Current burden of the transducer used in the Model 2164 recorder series is 2.5 VA. Remember that burden, by affecting the load either instrument sees, may cause an appreciable error during calibration.

Two Hall effect transducers are used in the Model 2164A series for three phase, three wire circuits. External wiring is shown in Figure 14.

By the same rule of thumb, three Hall effect transducers with outputs adding are used in the Model 2164B series for four wire systems. Wiring methods are shown in Figure 15.

Figure 16 depicts power relationships that are useful when working with Rustrak recording wattmeters.

USING EXTERNAL TRANSFORMERS:

To extend ranges in the Model 2164A series (3 phase, 3 wire) watt-recorder, use potential (E) and current (I) transformers as shown in Figure 17. Other 2164 models are wired in the same way, with the potential leads to both "E" terminals and leads from the current transformer connected to the "I" terminals.

Calibration

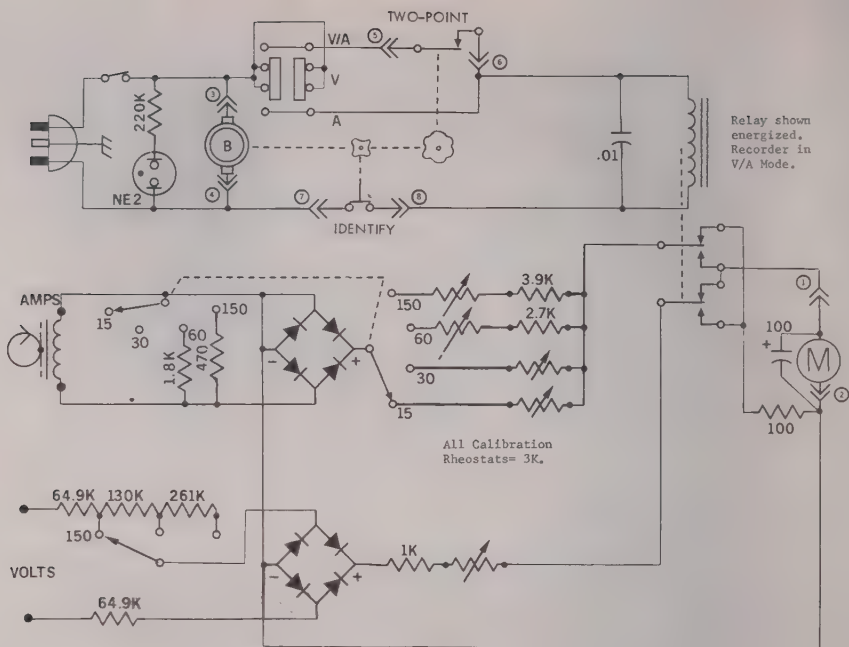
This series of recorders can be calibrated by comparing readings against lab type dynamometer standards available at 0.1 percent accuracy and in single or double elements, in the 2½ element configuration or in crossed-coils. To calibrate:

1. Adjust mechanical zero under front nameplate. Apply motor power.
2. Wire watt recorder across line(s) following installation instructions. Use caution. Currents are potentially lethal.
3. Wire dynamometer standard to the same source and using same load. Use caution. Currents are potentially lethal.
4. Adjust rheostat located in the lower half of the rear case panel, accessible by opening recorder and dropping front panel assembly. Calibrate on high end of scale since dynamometer has compressed scale at low end.

2113

The Model 2113 combines a three-range voltage recorder with a four range current recorder in one housing. Voltage only, current only, or both parameters alternately can be recorded on a 2-5.16" wide chart. Two-Point recording (see Features) results in an interrupted current trace for easy identification. Maximum chart speed is six inches per hour.

Ranges for both the current portion and voltage section are selected with a concentric rotary switch on the front panel; a slide switch selects voltage, current, or both parameters. Clip leads are used for voltage testing, and the clamp-on transducer is furnished with the instrument.



Operation . . .

1. Connect motor to line and, with no other connections made to recorder, let unit print several strikes. Keep slide switch in "V" or "A" position.
2. If trace isn't at zero, snap out nameplate from face of recorder and adjust mechanical zero.
3. Set range switch to correct voltage range and clip leads to voltage test points. No polarity need be observed. Put slide switch in "V" "V/A" position. In "V," trace will print only voltage being monitored while in "V/A" position, the trace will alternate between the voltage and an interrupted zero reading for the current trace. To familiarize yourself with the instrument, let it operate in "V/A" position for a few moments.
4. Set current range switch to highest range if line current approximation isn't known. Clamp transducer around a single conductor and place slide switch in either the "A" or "V/A" positions. The trace is interrupted only in the "V/A" position. Set range switch for on-scale trace.
5. After using, disconnect clip leads from circuit, unclamp current transducer and unplug recorder motor to save paper. Use caution when working with high voltages and currents.

Calibration...

First, mechanically zero the meter with no input voltage or current and with motor running.

VOLTAGE SECTION: Connect recorder clip leads to circuit similar to Figure 3. Set slide switch to "V" and front panel range switch to 150V. Adjust input voltage to 150 volts on standard meter.

Turn on recorder motor. Using Phillips screwdriver with insulated blade (or plastic alignment tool), adjust rheostat labeled 150V until trace prints steadily at 150 volts. Other ranges are automatically calibrated. **CURRENT SECTION:** Refer to Model 2107 for current calibration. Rheostats for each range are labeled on case rear and should be adjusted only when an accurate field (for the transducer) is available. Be sure to use an insulated blade calibrating tool only.



Each recorder described in this manual, except the 2113, can be combined with another recorder (AC, DC, Event, or Temperature) to make a "300 Series" instrument. The Series 300 recorders feature two separate Series 200 instruments in one housing and on one time base, sharing the same chart.

When shipped from the factory, the "300" recorder is equipped with a handle and rubber feet for portable operation. A modification kit for panel-mounting the instrument is available.

To determine operating and calibrating instructions for your recorder, separate the number into its two basic units. For example, if you purchase a 388R/3107, refer to instructions for the 288R and the 2107.

Terminals are always labeled and wiring information is printed inside the recorder case. Chart loading instructions also apply to the 300 Series.

FEATURES

F109A: Recorders with the Selective Command Print Feature,, F109A, have a solenoid-actuated striker rather than one which operates from the motor cam. (There is no cam.) No recording occurs until the solenoid is energized and the striker presses the stylus against the paper until released by the solenoid. Average duty cycle must not exceed 25 percent.

Connections are made through two binding posts on the case rear. They are labeled for correct voltages.

F109B: The Automatic Command Print Feature retains the cam-operated striker but the motor cam doesn't engage until the solenoid is energized. Recorder operates normally as long as solenoid is actuated. Duty cycle can be up to 100 percent.

Connections to solenoid are made through binding posts on the case rear. They are labeled for correct voltages.

F137: The Two-Point Feature is described and illustrated in the Model 2113 description. When featured in other models, the second or interrupted channel connections are made through binding posts on the case rear.

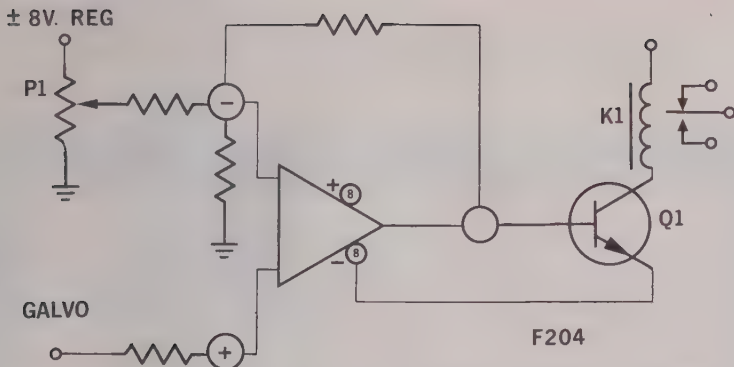
Certain limitations in chart and writing speed are inherent with this feature:

Writing Speed Strikes/Sec	Drive Motor rpm										
1 per 8 sec	1/2	1/32	1/16	1/8	1/4	1/2	3/4	1	1-1/2	2-1/2	3
1 per 4 sec	1	1/16	1/8	1/4	1/2	1	1-1/2	2	3	5	6
GEAR TRAIN ASSEMBLY NUMBER		1/8	1/4	1/2	1	2	3	4	6	10	12

F1A: The Quiet Feature reduces impact noise of the striker by changing the writing method to a pressing action. This is a mechanical feature only. The F1A is functional with all motors and gear trains available.

But since the cam arrangement differs from that of a regular recorder, the writing speed is based on strikes-per-15-seconds rather than strikes-per-second. Writing speed is about half as fast as that of a recorder without the F1A.

Strikes /15 sec.	Motor (rpm)
1	1/2
2	1
4	2
8	4
12	6
16	8
20	10
24	12
32	16



A recorder PM/MC meter used without amplification develops torque to move the stylus (pointer) by drawing current from the source. Since coil resistance remains constant, this current varies with applied voltage.

Milliameters and microammeters are low-range voltage meters which register voltage excursions at their terminals. These minute fluctuations represent a real change in the monitored circuit and can be used to control circuit quantities. That's the function of the F204 On-Off Controller Feature.

F 204

The F204 is a comparator amplifier driving a power transistor in series with a relay. SPDT contacts enable on-off control of parameters being recorded or the external wiring may be adapted to open or close any circuit to follow voltage excursions at the galvanometer terminals. By comparing voltage levels at the meter terminals with a stable reference voltage adjustable from the front panel, limits can be set for the relay switching function.

Both the reference voltage and the voltage impressed across the meter terminals are applied to the inputs of an operational amplifier.

Most operational amplifiers have two inputs, inverting (-) and non-inverting (+), indicating the phase relation between the input and the output. A positive signal applied to the positive terminal gives an in-phase or positive output. The output of a positive signal at the - input terminal is 180 degrees out of phase or -. If the signal is applied between the positive and - terminals, output voltage is zero.

Gain in all operational amplifiers is a minimum of 50,000 up to several million, and is considered infinite in gain calculations. Voltage gain, as a function of the ratio of R1 to R2, is $1 \div R1/R2$. For example, a gain of 10 requires 100 ohms at R1 and 900 ohms at R2.

All operational amplifiers are designed for stability with any amount of feedback, including a gain of one when R1 is zero and R2 is infinity.

The operational amplifier in the F204 is operated open-loop, that is, with no feedback. Its voltage gain, including the power stage driving relay K1, is about 125,000 or 0.2 millivolts at the input give 24 volts out.

Voltage across the galvo is applied to the positive input. P1 is the front panel setpoint adjustment that varies the reference voltage applied to the negative input.

When the voltage at the positive input terminal (the galvo input) is below or equal to the voltage at the - terminal (the reference), Q1 is cut-off and K1 is de-energized. If the positive terminal becomes more positive than the - terminal by more than about 0.2 millivolts (resolution), output increases to nearly positive 8 volts. Q1 then conducts and energizes K1.

Loading on the galvanometer, because the input impedance of the op amp is about 30 megohms, is limited 0.2 microamperes.

The operation, on a comparative basis, is simple. If K1 is to energize when the voltage across the galvanometer is 50 millivolts, P1 is adjusted to an input level of 50 millivolts. Other voltage levels are set accordingly.

Relay contacts are rated 5 amperes, resistive load, at 30 VDC or 115 VAC. The "normally-open" and "normally-closed" contacts can be adapted to almost any application whose functions lend themselves to on-off control.

Configurations (A or B) represent control direction. The A style closes the normally open contact below the setpoint and opens it above. This style is ideal for heat control because of its fail-safe characteristics. If power fails, the relay de-energizes, disconnecting the load.

Style B configuration closes relay contacts above the setpoint and opens them below. This style is suited for refrigeration control.

Besides these simple styles, two setpoint controllers are available. Style AA, featuring two control amplifiers both actuating the relay below the setpoint, are useful for control at one point and shut-down or alarming at the other. The same style can provide a simple logic for sorting or grading.

Style AB is useful is "go-no-go" applications, or, "low-in-high" type of information needs. Similar applications as with style AA are possible with the BB configuration but with control above the setpoint.

No controller is limited to its initial configuration since styles can be changed by the user.

The type of setpoint, whether low (A) or high (B), depends on galvanometer connections relative to the reference voltage. Since the relay energizes only when the positive terminal of the op amp is more positive than the - terminal, it is possible to change setpoint types by reversing connections to the galvo.

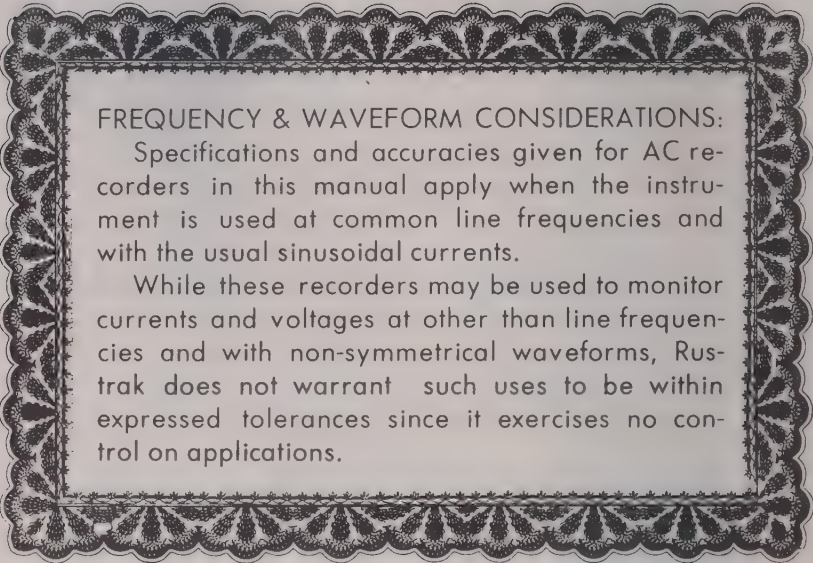
These connections are jumpers on the controller circuit board mounted on the case rear. The jumpers are located at the bottom of the PC board in this sequence:

Criss-cross or "X" jumpers denote an "A" type configuration while parallel (||) jumpers result in a "B" configuration.

To change setpoint types, remove four screws holding case rear to recorder housing. Then unscrew PC board from the rear panel. When soldering, be careful not to destroy the printed circuit board.

ADJUSTING PANEL KNOBS:

1. Apply signal to galvanometer for center scale reading.
2. Adjust controller setpoint knob until relay (de) actuates. Swing knob back and forth. Only slight movement of knob should be possible between on and off.
3. With galvo at center scale and reference pot at the control point, the knob should be at the center mark on its dial. If not, loosen set screw and move pointer to center mark.
4. Check knob pointer against scale at 0, 20, 40 60 and 100 percent points. A deviation of one division at any point is acceptable.



FREQUENCY & WAVEFORM CONSIDERATIONS:

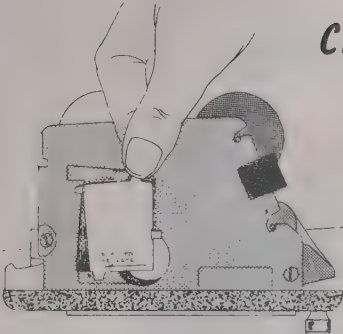
Specifications and accuracies given for AC recorders in this manual apply when the instrument is used at common line frequencies and with the usual sinusoidal currents.

While these recorders may be used to monitor currents and voltages at other than line frequencies and with non-symmetrical waveforms, Rus-trak does not warrant such uses to be within expressed tolerances since it exercises no control on applications.

FEATURES MUST BE PURCHASED AT TIME OF ORDER. ACCESSORIES CAN BE ADDED AT ANY TIME.

Accessories: A full line of accessories for mounting your recorder to custom panels and enclosures are available. Refer to latest catalog for details.

Changing Gear Trains...



Loosen thumbscrew at upper left and open recorder. Remove gear train spring. Move gear train in direction of arrow on its case. Lift out from top. Don't force or lift from bottom.

Insert new gear train bottom in first. Slide into position against arrow directions. Replace gear train spring.



CLEANING

The coating used on Rustrak recorders is Nextel Brand Suede Coating by 3M. It was chosen because of its toughness and visual qualities.

It can be cleaned with a damp sponge. The usual household spray and liquid cleaners can be used on tough stains without damage to the coating.

DC DRIVE MOTOR SPECIFICATIONS

INPUT VOLTAGE	TYPE	DC CURRENT REQUIREMENTS
6	DC Unregulated	24 MA, nominal
12		20 MA, nominal
24-28		10 MA, nominal
6	Solid-State Inverter/Motor (DC input)	2 RPM or less: 25 MA — over 2 RPM, consult factory
12		4 RPM or less: 10 MA — 6-16 RPM: 60 MA
24		2 RPM or less: 10 MA — 4-16 RPM: 30 MA

Gear Train Ratios

1/8 equals 480:1

1/4 equals 240:1

1/2 equals 120:1

1 equals 60:1

2 equals 30:1

3 equals 20:1

4 equals 15:1

6 equals 10:1

10 equals 6:1

12 equals 5:1

15 equals 4:1

30 equals 2:1

45 equals 1.5:1

60 equals 1:1

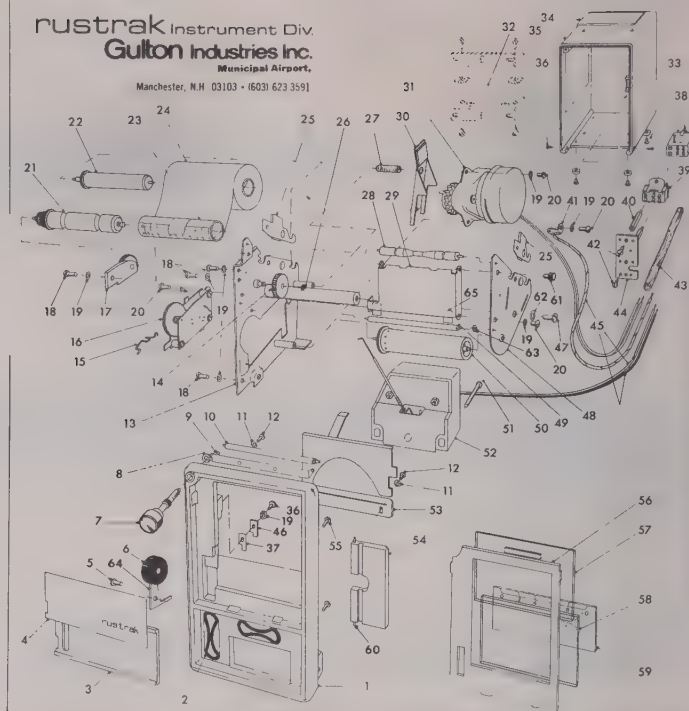
REPAIR.....

Your recorder should receive the care given a precision instrument. Most problems during use are caused by improper chart loading, incorrect wiring, or mishandling.

Should you need factory assistance to repair your instrument, pack it in a carton equal to the original packaging. Insure it to full value and ship prepaid. Please include a letter with your packing slip and give details on problem encountered or modification requested.

Send to:

Customer Service Department
Rustrak Instrument Division,
Gulton Industries, Inc.
Municipal Airport,
Manchester, N. H. 03103



ITEM	PART NO.	DESCRIPTION
1	C-4211-G1	FRONT PANEL ASSY
2	A-4553-P1	BELT, DRIVE
3	B-4131-P1	BEZEL, LOWER
4	A-4228-P1	NAMEPLATE
5	A-4218-P1	SCREW, SPECIAL
6	A-3280	THUMBWHEEL, CHART ADVANCE
7	A-4422-P1	THUMBSCREW
8	A-4557-P1	RING, RETAINING
9	B-4119-P1	BRACKET, FRICTION ROLLER
10	A-SA-1339-G1	FRICTION ROLLER ASSY
11	L1/2	LOCK WASHER, INTERNAL TOOTH #2
12	2-5661-8LG	MACH. SCREW, PAN HD, SST
13	B-4554-G1	LEFT HAND PLATE ASSY
14	A-2232	GEAR, IDLER
15	A-2354	SPRING, GEAR TRAIN
16	AS REQ'D	GEAR TRAIN ASSY
17	A-4478-G1	ARM AND GEAR ASSY
18	A-4061-16LG	MACH. SCREW, HD, SST
19	L1/4	LOCK WASHER, INTERNAL TOOTH #4
20	A-4061-4LG	MACH. SCREW, PAN HD, SST
21	B-4488-G1	TAKE UP ROLLER ASSY
22	B-2316-P1	ROLLER, SUPPLY
23	A-2254-P1	SLEEVE, CARDBOARD
24	AS REQ'D	PAPER, STRIP CHART
25	B-2348-P2	CLIP, RETAINING
26	5100 18-C MF	RING, RETAINING
27	A-4185-P1	SPRING, BRAKE
28	B-4220-P1	ROLLER
29	B-2474	PLATE, FRONT SUPPORT
30	A-4548-G1	BRAKE ASSY
31	AS REQ'D	MOTOR ASSY & CAM (115V, 60Hz, 2RPM)
32	B-4452-G1	HARDWARE KIT, PANEL MFG
33	B-4549-G1	RUBBER FEET, (4), WITH SCREWS
34	B-4313-P1	CARDHOLDER
35	D-2244-2LG	CASE, BASIC
36	A-4063-16LG	MACH. SCREW, FIL, HD, SST
37	A-4252-P1	RATCHET, CHART ADVANCE
38	A-4558-P1	SOCKET, CABLE
39	A-1559-P1	PLUG, CHASSIS
40	A-2229-P1	SPACER
41	A-4303-P1	LUG, DUAL
42	B-2341-4LG	MACH. SCREW, PAN HD, SST
43	A-4546-P1	TUBING, No. 3 234 I. O.
44	B-2456-P1	BOARD
45	A-4555	WIRE
46	A-4251-P1	STIFFENER, RATCHET
47	B-3245-16LG	MACH. SCREW, PAN HD, SST
48	A-4302-P1	PLATE, RIGHT HAND
49	A-2203-P1	ROLLER, CENTER
50	B-4550-G1	TIME DRUM ASSY
51	B-1211-5 16LG	MACH. SCREW, PAN HD, SST
52	AS REQ'D	ARM ASSY (1 MA.)
53	B-4457-G1	STRIKER AND ARM ASSY
54	C-4214-P2	LATCH, CHASSIS
55	A-4063-16LG	MACH. SCREW, PAN HD, SST
56	B-4117-P1	BEZEL, FRONT PANEL
57	B-4178-P1	WINDOW, ACCESS
58	B-4179-P1	WINDOW, BOTTOM
59	AS REQ'D	SCALE (STD.) ONLY
60	A-4551-P1	PIN, LATCH
61	A-4552-P2	CAP. SCREW, HEX SOC. HD
62	L1/8	LOCK WASHER, INTERNAL TOOTH #8
63	A-4157-P1	WASHER, NYLON
64	A-4219-G1	HINGE BRACKET ASSY
65	A-4089	SPRING, LEAF

- (1) † SPECIFY GEAR TRAIN NO. REQUIRED. INTERCHANGEABLE GEAR TRAIN AFFECTS SPEED. SEE CATALOG.
(2) * SPECIFY CHART PAPER STYLE.
(3) § WHEN ORDERING, INCLUDE MOTOR SPEED, VOLTAGE AND FREQUENCY. SEE CATALOG.
(4) SPECIFY METER PART NO. WRITE FOR PRICES
(5) □ SPECIFY SENSITIVITY, RANGE, PARAMETER AND SPECIAL MARKINGS, IF ANY.

RECORDER EXPLODED VIEW

Writing Factors

$$\text{CHART SPEED (inches per hour)} = \frac{\text{motor speed (rpm)} \times \text{gear train number}}{2}$$

gear train	1/8	1/4	1/2	1	2	3	4	6	10	12	15	30*	45*	60*
1/2	1/32	1/16	1/8	1/4	1/2	3/4	1	1 1/2	2 1/2	3	3 3/4	7 1/2	11 1/4	15
1	1/16	1/8	1/4	1/2	1	1 1/2	2	3	5	6	7 1/2	15	22 1/2	30
2	1/8	1/4	1/2	1	2	3	4	6	10	12	15	30	45	60
4	1/4	1/2	1	2	4	6	8	12	20	24	30	60	90	120
6	3/8	3/4	1 1/2	3	6	9	12	18	30	36	45	90	135	180
8	1/2	1	2	4	8	12	16	24	40	48	60	120	180	240
10	5/8	1 1/4	2 1/2	5	10	15	20	30	50	60	75	150	225	300
12	3/4	1 1/2	3	6	12	18	24	36	60	72	90	180	270	360
16	1	2	4	8	16	24	32	48	80	96	120	240	360	480

* separated dots

$$\text{WRITING SPEED (strikes per second)} = \frac{\text{motor speed (rpm)}}{4}$$

1/2	1	2	MOTOR (rpm)			10	12	16
ONE STRIKE EACH				3	2	5	3	4
8 Sec'	4 Sec'	2 Sec'	1 Sec	2 Sec'	1 Sec	2 Sec'	1 Second	

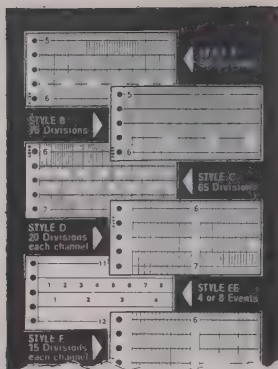
$$\text{TRACE DENSITY (strikes per inch)} = \frac{1800}{\text{gear train number}}$$

WEEKS, DAYS, HOURS PER ROLL

Drive Motor (rpm)	1/2	1	2	4	6	8	10	12	16
1/2	144 WKS	72 WKS	36 WKS	18 WKS	9 WKS	6 WKS	768 HRS	21 DYS	302.4 HRS
1	72 WKS	36 WKS	18 WKS	9 WKS	768 HRS	21 DYS	378 HRS	252 HRS	161.2 HRS
2	36 WKS	18 WKS	9 WKS	768 HRS	378 HRS	252 HRS	189 HRS	126 HRS	76.6 HRS
4	18 WKS	9 WKS	768 HRS	378 HRS	189 HRS	126 HRS	94.5 HRS	63 HRS	37.8 HRS
6	12 WKS	6 WKS	21 DYS	252 HRS	126 HRS	84 HRS	63 HRS	42 HRS	25.2 HRS
8	9 WKS	768 HRS	378 HRS	189 HRS	94.5 HRS	63 HRS	47.25 HRS	31.5 HRS	18.9 HRS
10	50.4 DYS	604.8 HRS	302.4 HRS	161.2 HRS	76.8 HRS	50.4 HRS	37.8 HRS	25.2 HRS	16.12 HRS
12	6 WKS	21 DYS	252 HRS	126 HRS	84 HRS	42 HRS	31.5 HRS	21 HRS	12.6 HRS
16	768 HRS	378 HRS	189 HRS	94.5 HRS	47.25 HRS	31.5 HRS	23.675 HRS	16.75 HRS	9.46 HRS
	1/8	1/4	1/2	1	2	3	4	6	10
	15	30*	45*	60*					

Gear Train

* separated dots



Your recorder "impact-prints" on pressure-sensitive chart paper whose white coating is bonded over a dark base. Graphs and other markings are laminated within the top coating. No ink, heat or electricity are needed to print.

During use, the recorder stylus pushes aside the top coat with each strike, exposing the black base paper. No buildup of coating material is found either on the stylus or on the paper; the chart paper resists smudges and is easily handled. It has an indefinite storage time, even after recording.

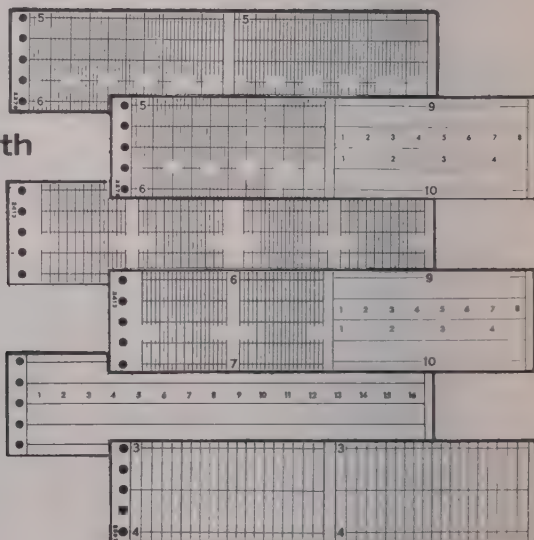
Each spool is 63 feet long,,allowing continuous recording for one month at a speed of one inch per hour. Useable scale width is 2-5/16" for single channel and 1" for dual channel recorders. Paper used in the 200 Series recorders is 2-5/16" wide while that for the 300 Series' instruments is 5-3/16" wide.

Notes may be written on the chart paper while the recorder operates by sliding down the access window. Any blunt stylus will do nicely.

Many chart styles are available for your recorder. Overlay and legend printing are typical of styles available on special order.

Series 300

Dual Width



"200" SERIES RECORDERS NOW WARRANTED FOR ONE YEAR

The image shows a dark, heavily textured surface, likely the cover or endpaper of an old book. The texture is irregular and fibrous, with many small creases and variations in tone. A vertical strip of lighter, yellowish-tan material runs along the left edge, separated from the dark area by a dashed line. This strip contains the text "200" SERIES RECORDERS NOW WARRANTED FOR ONE YEAR" printed in a serif font.

RUSTRAK MAKES MANY INSTRUMENTS NOT MENTIONED IN
THIS MANUAL. A COPY OF OUR LATEST CATALOG IS YOURS
FREE IF YOU DETACH AND MAIL THIS CARD.

3 $\frac{11}{16}$ "

Template

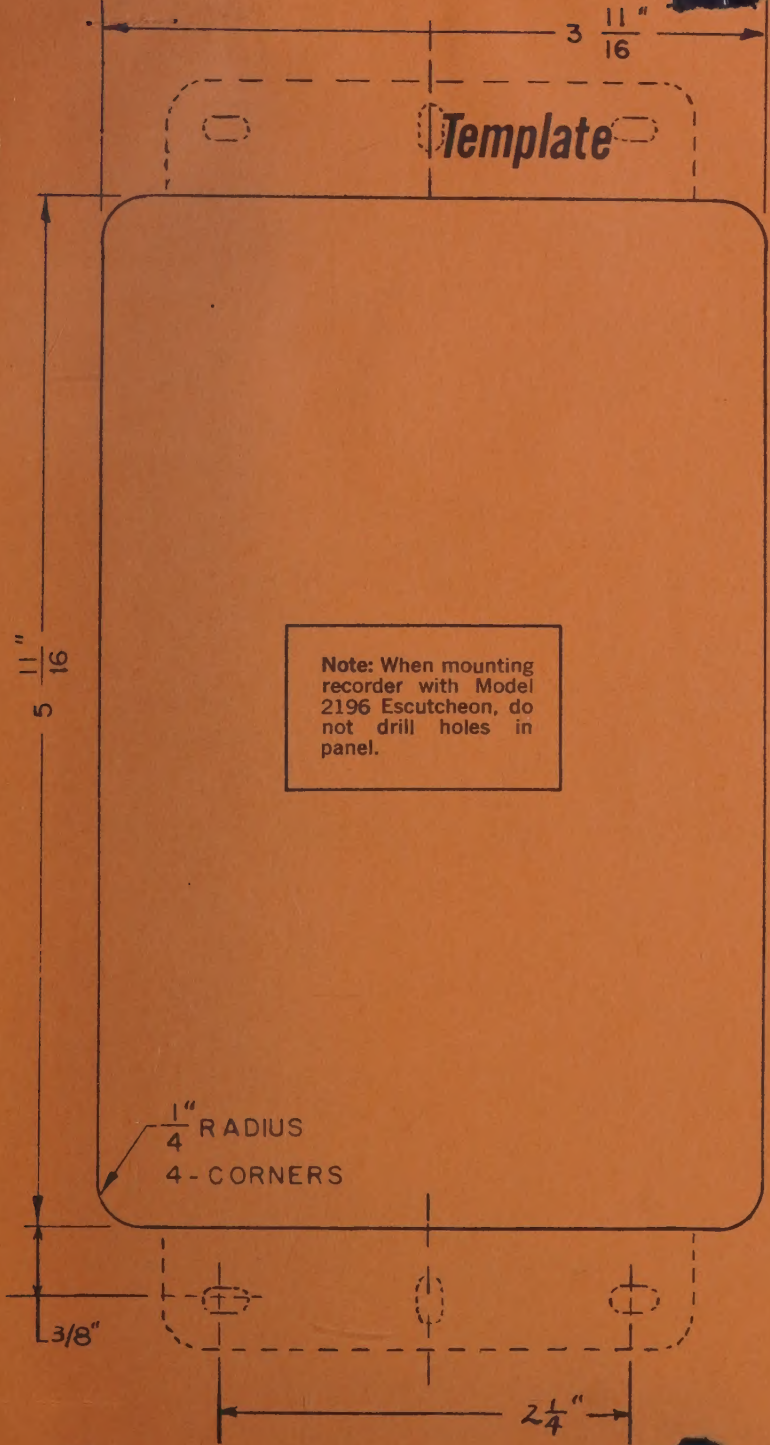
5 $\frac{11}{16}$ "

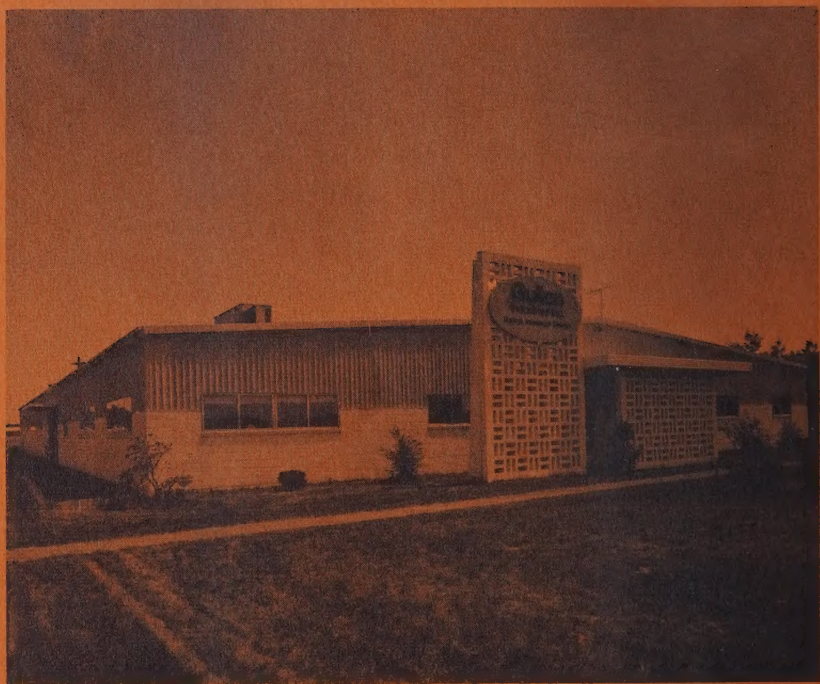
Note: When mounting recorder with Model 2196 Escutcheon, do not drill holes in panel.

$\frac{1}{4}$ " RADIUS
4 - CORNERS

$\frac{3}{8}$ "

2 $\frac{1}{4}$ "





rustrak THE MINIATURE
RECORDER PEOPLE
